# INVESTIGATION OF THE MAGNETIC SUSCEPTIBILITY OF THE REDUCED MAGNESIUM TITANATES $MgTiO_3$, $MgTi_2O_5$, $Mg_2TiO_4$

BY

HAROLD WILLIAM KATZ

B.S., Rensselear Polytechnic Institute, 1944
M.S., University of Illinois, 1948

## AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1952

URBANA, ILLINOIS

1952

# INVESTIGATION OF THE MAGNETIC SUSCEPTIBILITY OF THE REDUCED MAGNESIUM TITANATES $MgTiO_3$, $MgTi_2O_5$, $Mg_2TiO_4$

BY

HAROLD WILLIAM KATZ

B.S., Rensselear Polytechnic Institute, 1944
M.S., University of Illinois, 1948

## AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1952

URBANA, ILLINOIS

1952

R. UNIV.
BIBLIOTHEEK
LEIDEN

# INVESTIGATION OF THE MAGNETIC SUSCEPTIBILITY OF THE REDUCED MAGNESIUM TITANATES $MgTiO_3$, $MgTi_2O_5$, $Mg_2TiO_4$

## I. Object

To develop a technique for the determination of the amount of oxygen removed from the magnesium titanates $MgTiO_3$, $MgTi_2O_5$, and $Mg_2TiO_4$ for small reductions beyond the sensitivity of a 10 microgram chemical balance.

## II. Introduction

The removal of an oxygen atom leaves two unpaired electrons in the lattice, thereby producing a proportionate increase in the magnetic susceptibility. Advantage was taken of this fact in the problem of determining the amount of removed oxygen. The method consisted in measurements of the room-temperature magnetic susceptibility of reduced magnesium titanate rods which had a weighable amount of removed oxygen. This yielded a curve of magnetic susceptibility versus percent removed oxygen, which could then be extrapolated to find the amount of removed oxygen beyond the weighable range merely by measuring the magnetic susceptibility. In general it was found that magnetic susceptibility increased much faster than the percent of removed oxygen. In fact, for the Ba, Sr, and Calcium titanates it was found not possible to detect any change in weight except for those rods which were highly reduced. However, the magnetic susceptibility changed very appreciably over the same range. Unfortunately, since the change in weight was not observable for Ba, Sr, and Ca compounds, the technique described above for determining the amount of removed oxygen had to be abandoned for these compounds.

## III. Preparation and treatments of Rods

The three magnesium titanates were prepared in the

powder form according to the techinque given by Tanaka[1]. They were then extruded into rods and fired in air at 1300 degrees C. The final sintering was done in an oxygen atmosphere for twenty minutes at 1400 degrees C. Each rod was reduced in an atmosphere of 1/3 hydrogen and 2/3 helium in exactly the same manner except for the variation of one parameter, namely the reduction temperature.

## IV. Magnetic Measurements

A variation of the Curie-Chéneveau magnetic balance was constructed for the measurement of the room-temperature magnetic susceptibility. This method consists in placing a small sample in an inhomogeneous magnetic field and noting the resultant deflection of a torsion system supporting the sample. This deflection is then compared to that produced by a sample of known magnetic susceptibility. The system used in this problem was calibrated with standard solutions of $NiCl_2$.

## V. Results

The variation of magnetic susceptibility with removed oxygen was a monotonic function of the per cent removed oxygen. In all three compounds it was possible to extrapolate the curves toward zero reduction, and thereby determine the amount of removed oxygen beyond the weighing limit. However, one of the compounds, $MgTi_2O_5$, showed a remarkable peak in its susceptibility curve. This peak was found to occur at a critical reduction temperature of 950 deg. C. The volume magnetic susceptibility found in this case was of the order of $40 \times 10^{-6}$, i.e. ten times greater than those found for the other two compounds.

Measurements of the magnetic susceptibility as a function

---

1. Tanaka, Y. "Studies of the Reactions between Oxides in Solid State at Higher Temperatures; MgO and $TiO_2$" — Bull. Chem. Soc. Japan Vol. 16, p. 428, 1941.

of magnetic field strength for these critically reduced samples indicated that they were not ferromagnetic in the range of 400-1500 gauss. Neither did these rods show any change in crystal structure as determined by X-ray powder measurements.

It was possible to calculate approximately the theoretical value of the magnetic susceptibility to be expected for the compounds $MgTiO_3$ and $MgTiO_4$. The calculations were based on the assumption that the total magnetic susceptibility was due entirely to the magnetic properties of the electrons in the conduction band. By considering two contributing factors to the total magnetic susceptibility, a paramagnetism caused by electron spin and a quantum-mechanical diamagnetism of the free electrons, a calculated value of susceptibility was obtained which was somewhat higher than the experimental value. Part of the discrepancy was probably due to the fact that the number of free electrons was taken equal to the number of donors.

## VITA

Harold William Katz was born on June 4, 1923 in New York, N.Y. After graduation from Boys High School, Brooklyn, N.Y., he attended the Cooper Union Institute of Technology from 1939 to 1941. He was graduated from Rensselaer Institute of Technology in 1943 with the degree of Bachelor of Science in Electrical Engineering, with honors. In 1946, after three years in the United States Navy as a Radar officer, he became a full time instructor in the Department of Electrical Engineering at the University of Illinois until 1952. In 1948 he received the degree of Master of Science in Electrical Engineering from the University of Illinois. He was elected to membership in the following honorary societies: Eta Kappa Nu, Pi Mu Epsilon, Tau Beta Pi, and Sigma Xi.